ECOSYSTEM

* Functional unit of Nature – Ecosystem – organism interact → amongst themselves; with the surrounding physical environment.

Vary in size: From, Small pond. → to → Large forest or Sea.

* Many ecologists regard (entire biosphere) → GLOBAL ECOSYSTEM

(too big, too complex) → to be studied at one time, so

- Terrestrial Ecosystem
  - Forest
  - Grassland
  - desert-
- Aquatic Ecosystem.
  - Pond
  - Lake
  - Wetland
  - River
  - Estuary.

Man-made Ecosystem
- crop fields
- Aquarium

Ecosystem
- Input
  - 1) productivity
- Transfer of Energy
  - 1) Food chain / web
  - 2) Nutrient- cycling
- Output
  - 1) Degradation
  - 2) Energy loss.

ECOSYSTEM - STRUCTURE & FUNCTION

* Components → abiotic & biotic
  - interaction of these → result in → physical structure → that is characteristic for → Each type of ecosystem.

* Species Composition (of an ecosystem) is given by
  1. identification
  2. Enumeration

  of → plant species, animal species

* Stratification is → Vertical distribution of different species occupying different levels

Example – Layer of forests
- trees – Top layer
- Shrubs – 2nd Layer
- herbs & grasses – Bottom layer

* Components of Ecosystem are seen to function as a unit when you consider

1. Productivity
2. Decomposition
3. Energy flow
4. Nutrient-cycling

PEND

* POND → self sustainable unit
  - explains even the complex interactions that exist in aquatic ecosystem.
  - shallow water body → in which all above 4 components well exhibited.

Abiotic factors
1. Water → with dissolved: i) inorganic subst. ii) organic subst.
2. rich soil deposits → at bottom of pond.

* Rate of Function of pond regulated by
  1. solar input
  2. cycle of temperature
  3. day length
  4. other climatic factors

* Autotrophic components
  1) phytoplankton.
  2) Some algae
  3) Floating plants
  4) Submerged plants
  5) Marginal plants → found at edges

Consumers
1) Zooplankton (born)
   - free swimming
   - Bottom dwelling forms

Decomposers
1) Fungi
2) Bacteria
3) Flagellates
(especially abundant on bottom of pond)

* This system performs function of
  - any ecosystem
  - Biosphere as a whole

→ Conversion of inorg. → org. material with help of Radiant energy of sun by autotrophs

1. decomposition
2. Mineralisation

of dead matter → to release nutrients back for use of autotrophs

consumption of autotrophs by heterotrophs

There is UNIDIRECTIONAL MOVEMENT OF 'ENERGY' towards higher trophic levels & its 1. dissipation & 2. loss as heat to environment

PRODUCTIVITY

* Basic requirement (for ecosystem to [sustain] [function]) — constant input of Solar energy.

* PRIMARY PRODUCTION → Amt of biomass / organic matter produced per unit area over a time period by plants during photosynthesis

expressed in terms of

[Kcal m^{-2}] * (Energy) *

[g m^{-2}] * (weight) *

Rate of biomass production → Productivity

expressed in

$gm^{-2}\ yr^{-1}$ | $(kcal\ m^{-2})yr^{-1}$

divided into

Gross Primary Productivity (GPP)

Rate of production of organic matter during photosynthesis

(NPP) Net primary Productivity

A considerable amt of GPP is utilised by plants in respiration

[GPP − R = NPP]

available biomass for consumption to heterotrophs

herbivore | Decomposers

* SECONDARY PRODUCTIVITY → Rate of formation of new organic matter by CONSUMERS.

* Primary Productivity

depends on (1) → plant species inhabiting a particular area.

also on (2) → Variety of Environmental factors

(1) availability of nutrients

(2) photosynthetic capacity of plant

(3) varies in different types of Ecosystem.

imp

* Annual NET Primary productivity (of WHOLE BIOSPHERE) → 170 billion tons (dry weight of organic matter)

Productivity of Oceans → 55 billion tons (despite occupying 70% of surface)

Land → 115 billion tons

DECOMPOSITION → Earthworm - Farmer's friend

(1) help in breakdown of complex organic matter

(2) Loosening of soil

Decomposers break down complex organic matter into inorganic substances like CO_2, water, nutrients

Detritus → raw material for decomposition

→ dead remains of plants (leaves, bark, flowers) & animals (fecal matter)

Fragmentation → Breakdown detritus into smaller particle
by [detritivores] → earthworm.

Leaching → Water Soluble inorganic nutrients go down into soil horizon & get precipitated as unavailable salts

Catabolism → Bacterial enzymes, Fungal enzymes degrade detritus into simpler inorganic subst.

* All above proces of decomposition occur simultaneously on detritus

⊙ During decomposition in Soil occurs → ★ HUMIFICATION, ★ MINERALISATION

Humification

Leads to accumulation of
★ dark coloured
★ Amorphous substance
→ HUMUS → colloidal so Reservoir of nutrients

① highly resistant to microbial action
② Decompose at an extremely slow rate

Mineralisation

Humus degraded by microbes releasing inorganic nutrients

★ DECOMPOSITION → largely an oxygen requiring process.

Rate of decomposition controlled by
- chemical composition of detritus
- environment / Climatic factors → Temperature, Soil moisture

Effect on soil microbes

in a particular climatic condition

Decomposition Rate

slower if detritus rich in lignin, chitin

quicker if Detritus rich in nitrogen, water-soluble substance like sugars.

* ① Warm & ② Moist Environment → favour decomposition

* ① Low temp. & ② anaerobic conditions → inhibit decomposition → results in building up of organic materials

ENERGY FLOW

Sun → only source of energy for ALL ecosystems [Except: Deep sea hydrothermal vents]

of incident solar radiation

< 50% → PAR (photosynthetically active radiation)

Plants capture 2-10% of PAR → this small amt of energy sustains entire living world.

We know → Plants, Photosynthetic Bacteria (autotrophs)

Food ← from simple inorganic material

Sun's suns energy to make

* All organisms dependent on for food → Producers either directly / indirectly

Unidirectional flow of ↓ energy from sun to producers then to consumers.

* Ecosystem not exempt from 2nd Law of thermodynamics

need constant supply of energy to synthesise molecules they require to counteract ↑↑ disorderness towards Universal tendency

* Producers — green plants in ecosystem

Terrestrial Ecosystem
- Herbaceous
- Woody
} plants

Aquatic Ecosystem
- phytoplankton
- Algae
- Higher plants

* Chain / Web of food formed due to interdependency

* No energy trapped into a org remains in it forever

Energy trapped (by producer) passed on to consumer

or Organism dies → death of org. starting of Defines Food chain / Web.

* All animals — Consumers / Heterotrophs.

Primary Consumers	Secondary Consumers	Tertiary Consumers
(feed on producer) → HERBIVORE	(Eat an animal which in turn eat plants)	Secondary Carnivore
Ex. Insects, Birds, Mammals in Terrestrial Eco., Molluscs in Aquatic Eco.	Primary Carnivore (eat herbivores)	(Animals which depend on primary carnivore for food)

Simple Grazing Food Chain (GFC)

Grass (Produces) → Goat (Primary consumer) → Man (secondary consumer)

Detritus Food Chain (DFC) — begins with → ① ② dead organic matter

made up of → Decomposers (Heterotrophic organisms) — also known as → SAPROTROPHS (↳ to decompose)

mainly → [Fungi, Bacteria] — they meet their energy requirement by → degrading dead organic matter / Detritus

* Decomposers — secrete → digestive enzymes — break down → dead & wastes materials into simple, inorganic material → absorbed by them.

* In Aquatic Ecosystem — major conduit for energy flow → *GFC*

* In Terrestrial " — " → *DFC* rather than GFC.

* DFC — can be connected to → GFC (at some level) → some org. of DFC are a prey to GFC animals.

make → Food web

natural interconnecting of food chain

cockroaches, crows → In Natural Ecosystem

Both are OMNIVORES.

* Organism occupy a place in natural surrounding / community — acc to their → Feeding Relationship with other organisms.

* Organisms occupy a specific place in food chain (TROPHIC LEVEL) — based on → Source of nutrition / food.

* Amt. of energy ↓↓ decreases at → successive trophic levels.

* When organisms dies — it is converted to → Detritus / Dead biomass → serves as ENERGY SOURCE for decomposer.

* Organisms at each trophic level — depend on those at → lower trophic level → for energy demands

Standing Crop → Each trophic level has certain mass of "Living material" at a particular time

measured as → ① Biomass (mass of living organism)
OR
② Number in a unit- area.

* Biomass of a species expressed in → fresh weight
→ Dry weight → more accurate

* No. of Trophic levels (in GFC) restricted as → Transfer of energy follows 10% law

Each Trophic level ← transferred from lower one ← to ← only 10% of energy

* In NATURE → it's possible to have so many levels → producer → herbivore → primary carnivore → secondary carnivore

ECOLOGICAL PYRAMIDS → plz see Diagrams in NCERT

→ gets similar shape whether you express ① food ② Energy relationship b/w organisms at different trophic levels

* Relationship expressed in terms of → Number, Biomass, Energy

* Base of each pyramids — producers / 1st trophic level.
* Apex represents — Tertiary / Top level consumer.

* Given organism - may occupy more than one trophic level simultaneously

* Trophic level represents → Functional level
does not represent → ~~species~~

* Species may occupy more than one trophic level in same ecosystem at same time.

Eg.

SPARROW → primary consumer - eats → seeds, fruits, peas
→ secondary consumer - eats → insects, worms.

* In most Ecosystems → All pyramids of Number, Energy, Biomass → upright

* Energy at lower trophic level > higher level.

• producers > Herbivore (in both number & biomass)
• Herbivore > Carnivore

Inverted pyramids → of Biomass — in sea bcz Biomass of fish >> phytoplankton
→ of Number — Tree ecosystem

* Pyramid of Energy — always upright — bcz at next trophic level some energy always lost as heat.
↳ Each bar in pyramids — amt of energy present at each trophic level in a given time or annually per unit area.

Certain Limitations in Ecological Pyramids

- does not take into account the same species belonging to 2 or more trophic levels
- Assumes a simple food chain (something that never existed in nature) does not accomodate a food web.
- Saprophytes are not given any place in ecological pyramids even though they play vital role in ecosystem

ECOLOGICAL SUCCESSION

Important Characteristic of Community → ① their structure & ② composition changes constantly in response to changing environmental conditions.

★ This change is ① orderly & ② sequential
③ parallel with the changes in physical environment

These changes lead finally to Community — that is near equilibrium with environment
↓
CLIMAX COMMUNITY

* Gradual / Fairly predictable change in the species composition of a given area is called ECOLOGICAL SUCCESSION

* During succession → some species colonise an area & their population become more numerous, whereas population of other species ① decline & ② even disappear

* Entire sequence of communities that successively change in a given area.
↓
SERE (S)

* Individual transitional communities — termed as → SERAL STAGES / SERAL COMMUNITIES

* In successive seral stages there is a
  - change in diversity of species of organism
  - increase in no. of species & organisms
  - increase in Total biomass

* Present day communities (in world) is bcz of succession that occured over millions of years since life started on earth

* Succession
* Evolution
→ parallel process at that time

* Succession → starts in an area where no living organisms are there.

Primary Succession

* NO living org. ever existed

Eg →
- Bare rock
- Newly cooled lava
- Newly created pond / Reservoir

* Establishment of new biotic community is GENERALLY SLOW.
  - before this is established there should be Soil
* Depending mostly on climate
  - it takes natural process
  - 100 – 1000's yrs to produce FERTILE SOIL on Bare Rock.

Secondary succession

* Area that somehow lost all the org. that existed there.

Eg – Abandoned farm lands
Burned forests
Cut forest
Lands have been flooded.

* In areas, where natural biotic communities have been destroyed.
* Since some ① soil / ② sediment present
  - faster than primary succession

* Description of ecological succession usually focuses on changes in vegetation.
  - these vegetational changes in turn affects Various types of animals. for food, shelter
  - succession proceeds → number, types of animals, decomposers } also change

* At any time during primary / secondary succession
  - Natural disturbance
  - Human induced disturbance (fire, deforestation)

  can convert Seral stage of succession in Particular Earlier Stage

* Such disturbances create new conditions that
  - encourage some species
  - discourage / eliminate other species

Succession of Plants

Based on Nature of Habitat
- In wet areas → **Hydrarch Succession** (hydric → mesic)
- In dry areas → **Xerarch succession** (xeric → mesic)

Mesic – • medium water condition
• neither too dry, nor too wet

* Species invading bare area – Pioneer species

* Primary succession on rocks – Lichens → secrete acid to dissolve rocks.
  - help in weathering & soil formation
  - these pave way to → BRYOPHYTES (very small plants) → able to take hold in small amount of soil.
  - Bryophytes succeeded by → Higher plants → after several more stages → Stable Climax Forest Community is formed

* "Climax community remains stable as long as environment remains unchanged." (Imp)

* With time, Xerophytic habitat gets converted into → Mesophytic one.

PRIMARY SUCCESSION IN WATER → Pioneers – small phytoplanktons
↓ replaced by
Rooted submerged plants → Rooted floating angiosperms → Free floating plants → Reed swamp → Marsh meadow → scrub → Finally trees.

* Climax – Forest (Imp)
* With time water body converted into land. (Imp)

SECONDARY SUCCESSION → species that invade depends on
- condition of the soil
- availibility of water
- environment
- seeds/propagules present

↳ Soil is here → rate of succession much faster
↓
hence climax reached more quickly.

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★ Primary succession → very slow process.
↘ takes thousands of years for climax to be reached.

★ All succession whether taking place on → Land
↘ Water
→ proceeds to similar climax community
↓
MESIC.

NUTRIENT CYCLING (BIOGEOCHEMICAL CYCLES)

living org. rocks, air, water

movement of nutrient elements through various components of ecosystem.

Organisms need constant supply of nutrients to → grow
→ reproduce
↘ regulate various body function

STANDING STATE – The amount of nutrients (C, N, P, Ca etc...) present in soil at a given time.

varies in
- different kinds of ecosystem
- on seasonal basis

★ Nutrients never lost from ecosystem → recycled time & again indefinitely.

Gaseous cycle	Sedimentary cycle
Nitrogen, Carbon	Sulphur, Phosphorus
Reservoir – atmosphere	Reservoir – ~~sedimentary~~ Earth Crust.

Function of Reservoir – to meet with deficit which occurs due to imbalance in rate of influx & efflux.

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Environmental factors → Soil, Moisture, pH, Temperature } regulate the rate of release of nutrients into the atmosphere.

ECOSYSTEM – Carbon Cycle → occurs through • atmosphere • Ocean • Living & dead org.

'C' consitutes 49% of dry weight of organisms
↳ next to water

Reservoir that regulates amount of C in atmosphere

Total Global Carbon → 71% 'C' – dissolved in OCEANS
→ 1% 'C' – in atmosphere.

Fossil fuels – also Reservoir of Carbon.

★ 4×10^{13} kg carbon is fixed annually in biosphere through photosynthesis

★ Considerable amount of carbon returns to atmosphere as CO_2 through – respiratory activities of producers & consumers.

★ Decomposers – contribute substantially to CO_2 pool by processing of – waste materials & dead organic matter of land or oceans.

★ Some amount of fixed carbon is LOST TO SEDIMENTS & removed from circulation.

Additional sources for releasing CO_2 in the atmosphere —
- Burning of → Wood → Forest fires
- Combustion of → Organic matter → Fossils fuels
- Volcanic activity

Human Activities have significantly influenced Carbon cycle.
- Rapid Deforestation
- Massive burning of fossil fuel (for energy Transport) } ↑↑ rate of release of CO_2 into atmosphere.

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ECOSYSTEM – Phosphorus Cycle

→ major constituents of → Biological membranes, Nucleic acid, Cellular energy Transfer systems

↓

Many animals need it (large quantities) of 'P' to make shells, Bones & Teeth.

★ Natural Reservoir of P – (Rock) (contains 'P' as phosphates)

When weathered minute quantity of phosphate dissolve in soil solution & is absorbed by the roots

★ Herbivore & other animals —get 'P' from→ Plants

★ Waste products, Dead organisms —decomposed by→ phosphate-solubilising bacteria releasing PHOSPHORUS.

★ Unlike 'C' cycle, no respiratory release of 'P' in atmosphere.

⊗ 2 Differences b/w Carbon & Phosphorus Cycle:

1) Atmospheric inputs of phosphorus through rainfall is <<< than Carbon inputs.

2) Gaseous exchanges of phosphorus b/w organisms & environment are negligible.

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ECOSYSTEM SERVICES

Healthy ecosystem —base for→ wide range of economical, environmental, Aesthetic goods & services

Products of ecosystem process] named as → Ecosystem Services

⊙ Healthy forest Ecosystem →
- cycle nutrients
- mitigate floods
- purify air & water
- Mitigate droughts
- provide storage site for carbon
- provide aesthetic, cultural, spiritual value
- maintain biodiversity.
- Pollinate crops
- provide wildlife habitat
- generate fertile soils

Value of such services difficult to determine → Biodiversity should carry a hefty price tag

* ROBERT CONSTANZA & his colleagues → very recently tried to put price tags ~~$~~ on Nature's life supporting services

* Researchers —have put→ Avg. price tag of US $ 33 trillion / a year on fundamental ecosystem services.
  - nearly twice the value of the global GNP (gross national product) → US $ 18 trillion.
  - but are taken for granted bcz they have free.

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★ Out of the total cost of various ecosystem services :

1) Soil formation accounts for 50 %.

2) Recreation, Nutrient Cycling → are less than 10% each

3) Climate Regulation, Habitat for Wildlife → about 6% each

→ Few (New) Points from SUMMARY :

1) Atmosphere Or Hydrosphere is reservoir for gaseous type of cycle (carbon)

★ 2) Biotic community — Dynamic

Undergoes changes with the passage of time

↓

are sequentially ordered

↓ constitute

ecological succession

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